Abstract for iSAIRAS, Montreal, June 2001

AUTONOMOUS TRANS-ANTARCTIC EXPEDITIONS: AN INITIATIVE FOR ADVANCING PLANETARY MOBILITY SYSTEM TECHNOLOGY WHILE ADDRESSING EARTH SCIENCE OBJECTIVES IN ANTARCTICA

Frank Carsey and Paul Schenker, California Institute of Technology Jet Propulsion Laboratory; Jacques Blamont, Centre National d'Etudes Spatiales; S. Prasad Gogineni, University of Kansas; Chris Rapley, British Antarctic Survey; and William Whittaker, Carnegie–Mellon University

The commonwealth Trans-Antarctic Expedition (TAE) successfully accomplished the first surface crossing of Antarctica in 1957-58. The trip took 100 days at an average speed close to 34 km/d; the traverse had numerous close calls in crossing crevasses, and experienced several delays from mechanical breakdowns. Along the route, scientific data were acquired on ice depth, snow and ice density, weather and geology. TAE was an immense undertaking; it required 17 tracked vehicles, 4 aircraft, 35 people on the ice, and hundreds of tons of equipment and supplies; bases at each end had to be established a year ahead of time. The TAE Ross Sea terminus, Scott Base, is the current New Zealand Antarctic base. Antarctic traverses actually began earlier in the century and continue today in the form of the International Antarctic Scientific Expeditions (ITASE; see http://www.antcrc.utas.edu.au/scar/itase/itase.html) program. Over the past century, the approach to polar traverses has changed in detail, but not in basic conduct; tracked vehicles towing sleds grind across the ice, avoiding crevasses and other hazards, and taking data both en-route and at periodic stops.

We in the international space and Earth science communities are currently examining and developing the technologies to perform long-range Antarctic scientific traverses using autonomous robotic vehicles. It is clear that these mobility systems could efficiently accomplish traverses addressing interesting Earth science objectives using modern miniature, low power, computer controlled instruments. Such traverses would constitute useful and challenging test environments for systems to be used in the planetary environments. In addition, the elapsed time since the early polar traverses is such that studies of ice sheet change could be addressed through carefully designed revisits of key historical traverse segments. If we elect to re-enact TAE with autonomous rovers, the task would be a far more modest undertaking; it could be conducted with a few hundred kilograms of equipment and some air-support flights. Finally, Antarctica is a remarkably useful analog to numerous planetary environments; we note in particular that the surface conditions on the polar plateau are quite similar to those of Mars, and the scientific and in-situ engineering issues are quite similar to those of the explorations of Europa and Titan.

In summary a long-range Antarctic traverse using autonomous robotic vehicles would accomplish:

A. A scientific traverse of Antarctica making new observations,
B. An Earth science study in ice-sheet change (supporting the ITASE project goals),

C. A demonstration of long-range autonomous vehicle technology of the sort that will be essential to Mars exploration (manned and autonomous) as well as other planetary studies,
D. A demonstration of autonomous vehicle capability which could save significant expense in Antarctic and Arctic field science and operations,
E. An electrifying educational outreach project for the world's school children,
F. An exciting demonstration of space technology to capture the public imagination, and
G. An international collaboration with numerous benefits to all participants.

Several approaches to Antarctic robotic traverse missions can be considered. There might a convoy of several rovers, each from a different country, corporation, or university; the rovers might deploy instruments from still other institutions or countries; and some rover-provider objectives might be non-scientific but still interesting and valid. Given the natural hazards (e.g., crevasses, topographic features, soft deep snow), the rovers will probably have to be roped together for most or all of the time. The capabilities of autonomous rovers and instruments are in steady development; an important task is to determine what can be done at the selected time, at what reliability, and at what cost. The program itself should clearly be international, and this collaboration must be organized on several levels. Finally, testing programs will be required, possibly at other (more convenient) sites where this general approach could be useful.

The project development program would include scientific and operational autonomy directing other subsystems, e.g., miniature, computer-controlled instrumentation, power and communication systems, navigation and hazard avoidance, multi-rover cooperative tasking, materials, and the like. The spectrum of science that can be addressed spans fine-scale ice sheet bed topography, ice dynamics, ice chemistry, snow and ice grain size, subglacial thermal and mechanical processes, and other areas. An initial traverse concept is that of sounding radar investigations of the ice sheet to link planned ITASE segments. The technology of sounding radar continues to advance in significant ways. At this time novel, low power, fine resolution radar systems can be designed to study recent snow accumulation in the top 200 m, isochronous layer behavior enabling reconstruction of past ice deformation, and basal properties and processes.

We recommend that an international program of autonomous rovers, deployed in addressing Earth science goals in Antarctica and similar, remote sites, be closely examined, and, if found useful to both Earth science and planetary technology development, be aggressively pursued by the autonomous systems community in collaboration with the planetary technology and Earth science communities. Our intention is to initiate discussion of implementation possibilities for the development and exercising robotic autonomous systems in the service of Earth and space science.